Silvics and Partial Cutting Field Cards

Species List

Abies amabilis (Amabilis fir – Ba)
Abies grandis (Grand fir – Bg)
Abies lasiocarpa (Subalpine fir – Bl)
Thuja plicata (Western redcedar – Cw)
Pseudotsuga menziesii (Douglas-fir – Fd)
Tsuga mertensiana (Mountain hemlock – Hm)
Tsuga heterophylla (Western hemlock – Hw)
Larix occidentalis (Western larch – Lw)
Pinus contorta var. *latifolia* (Lodgepole pine – Pl)
Pinus monticola (Western white pine – Pw)
Pinus ponderosa (Ponderosa pine – Py)
Picea sitchensis (Sitka spruce – Ss)
Picea spp. (Interior spruce – Sx)
Chamaecyparis nootkatensis (Yellow-cedar – Yc)

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Silvics of Some Common Tree Species of British Columbia as they Relate to Partial Cutting

The following set of 14 field cards includes the major conifer species in BC. The cards are intended to assist forest managers to match tree species characteristics with management objectives in their partial cutting prescriptions.

Note: Species suited to ecological units are rated and presented by site series within biogeoclimatic units in the *Establishment to Free Growing Guidelines* (1995). The guidelines provide guidance on tree species selection for even-aged, primarily clearcut conditions. Use the guidelines to determine the range of species suited to the area in question. The field cards and other silvics references will help to further fine-tune the use of species within silvicultural systems planning.

When using systems other than clearcutting, ecological tolerances and silvical characteristics of the trees to be managed must be further assessed to determine leave-tree acceptability and opportunities for regeneration. The field cards provide information on a range of topics of interest for partial cutting prescriptions.

The compilations are taken from many sources. The recent publication *The Distribution and Synopsis of Ecological and Silvical Characteristics of Tree Species of British Columbia Forests* (January 1998) by K. Klinka, J. Worral, L. Skoda, P. Varga, and V.J. Krajina, provided detailed information used in these cards. We acknowledge their work and recommend that those interested in a more comprehensive coverage of the silvics of British Columbia species obtain a copy.

Brief overviews of the topic headings and sources of information are provided below.

Suitable Silvicultural Systems

This section summarizes the range of silvicultural systems based on silvical characteristics and specific tolerances of the species. It is not exhaustive but can trigger the thought process necessary when leaving stems on-site.

Tolerances

A range of tolerances is presented. They include shade, frost, high temperatures, water deficits, water surpluses, and nutrient status. The information on tolerances is taken largely from Klinka et al. 1998. Species-specific sections of *Silvics of North America* (1990) were used to provide additional information in some cases.

Effects of Harvest Damage on Understorey Stems

This section provides a discussion of harvest damage as it relates to the potential for advanced regeneration to become crop trees. See the reference list for potential information sources.

Effects of Damage on Leave-trees

This section provides a discussion of harvest damage as it relates to decay in trees left post harvest. Forest health sources are provided in the references.

Natural Regeneration

Seven categories that relate to natural regeneration are summarized: prolific seed years, seed travel distance, seed distribution method and timing, seed production, seed losses and germination needs. This information provides a level of awareness when contemplating natural regeneration of the species. Information sources include Klinka et al. (1998), *Silvics of North America* (1990) and Eremko et al. (1989).

Strategies for Enhancing Natural Regeneration

This section takes the information provided in the preceding section and provides a summary for the species.

Growth Potential

A list is provided of the biogeoclimatic units in which the species grows. It provides a range of site index at breast height age 50 ranges from the *Site Index Estimates by Site Series* (1997) and provides optimal growing conditions as described by Klinka et al. (1998).

Windthrow – Snow-breakage

Windthrow resistance based on rooting structures and growing environment are reviewed and rated (Klinka et al. 1998). Snow-breakage is addressed based on ratings of Klinka et al. (1998).

Major Pests

Where possible, pests that can be affected by partial cutting are discussed. This is by no means an exhaustive section. Forestry Canada has a range of excellent publications and a web site that should be used to get up-to-date information. Local experts, including regional entomologists and pathologists, should also be contacted regarding local issues. See the reference list for relevant publications.

General

An overview of silvical characteristics as they relate to partial cutting is provided. This section should be added to by individual practitioners as they see successful prescriptions within their working area.

References

The information presented on these field cards was gleaned from a number of sources, many of which were originally compilations in their own right. Some useful sources that were used in creating the field cards are listed below.

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Amabilis Fir and Partial Cutting

Abies amabilis (Ba)

Suitable Silvicultural Systems

✓ **Natural and Nurse-tree Shelterwoods** – Well suited due to high shade tolerance. Note: For all overstorey harvests, take care not to damage understorey stems to avoid heart and butt rot.

○ **Other Forms of Shelterwood** – Suitable as some shade is good for germination. A full removal cut maximizes the growth potential of the regeneration layers. Avoid damaging regeneration layers.

✗ **Single Tree Selection or Irregular Shelterwoods** – Carefully plan to minimize windthrow and stem damage; consider strip or group applications.

✗ **Seed Tree Systems** – Not generally suitable due to risk of windthrow of seed trees.

Tolerances

✓ **Shade** – Very shade tolerant.

○ **Growing Season Frost** – Moderate tolerance; root tolerance to excessive cold is low requiring a snowpack for protection restricting its geographic range to some extent.

✗ **Heat/Drought** – Low tolerance to high temperatures and water deficits; protection needed on hot and dry sites.

✗ **Fire** – Low tolerance due to thin bark and predominantly shallow roots.

✓ **Water Surplus** – Tolerant of water surpluses; common on moist to wet sites.

✓ **Nutrients** – Tolerant of poor nutrient status.

Effects of Harvest Damage on Understorey Stems

○ Entry of Indian paint fungus (*Echinodontium tinctorium*) through branch stubs is a serious concern. However, damage to understorey stems is not a problem if winter harvested under a heavy snowpack.

Effects of Harvest Damage on Leave-trees

✗ Thin-barked species highly susceptible to *Heterobasidion annosum* root and butt rot. Harvesting damage promotes entry and expression of a range of other butt and heart rots.

Natural Regeneration

Prolific Seed Years

Variable – good crops approximately every 3 years.

Seed Travel Distance

Most within 1 tree length. Heaviest seed of BC native conifers.

Seed Distribution Method and Timing

Wind dispersed. Begins in September, most shed by the end of October. Overwinters in the forest floor. Can be shed as late as April.

Seed Losses

Insect damage of seed can be considerable in all *Abies* species.

Germination Needs

○ Germinates in the spring following dispersal.

✓ Germinates on all substrates.

○ Survival highest on mineral soil, but will often survive on other substrates.

✗ Early mortality often associated with adverse climate effects and competing vegetation.

Strategies for Enhancing Natural Regeneration

✓ Leave good seed producers (>50 years old), provide some exposed mineral soil, and control brush.

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✓ Recommended ✗ Use caution ○ Informational

Amabilis fir (Ba)

Growth Potential

○ Productivity ranges from SI 8 to 28 m at breast height at 50 years.

Poorest growth is found in the MHmm subzones; greatest growth found on a range of CWH subzones and site series.

✗ Very slow initial height growth in low light conditions.

✗ Poor growth on dry sites, warm growing season climate (non-maritime) and on decaying wood. Do not rely on advanced regeneration where any of these conditions occur.

Windthrow[1] – Snow-breakage

○ Variable resistance to windthrow depending upon location. Generally better rooted on drier sites (forms sinker or tap roots).

✗ Reducing density around Ba (e.g., removing Hw) on moist sites puts Ba at risk of wind throw.

✓ Tolerant of heavy snow loads.

Major Pests

✗ Balsam woolly adelgid is the most significant insect pest at elevations below 600 m. *There are quarantine restrictions in some areas for seedling transportation (only within the Vancouver Forest Region at present).*

✗ Highly susceptible to many common heart rots including *Echinodontium tinctorium, Hericium abietis* and *Phellinus pini.*

✗ Also susceptible to spruce budworm (*Choristoneura occidentalis),* western balsam bark beetle (*Dryocoetes confusus).* Insect attacks are generally not as big a problem as disease agents.

✗ Partial cutting may increase the potential for western spruce budworm if a significant Ba understorey is retained.

✗ Partial cutting may increase inoculation by root diseases such as *Armillaria ostoyae* and *Heterobasidion annosum* when present.

General

○ Ba grows alone or in combination with a range of coastal species: Hw, Hm, Yc, Cw, Bg, Bl, Se, Ss, and Fdc.

○ Grows in the hypermaritime, maritime, submaritime MH, wetter maritime, and submaritime CWH and as a minor component in northern ICH and ESSF (Prince Rupert Forest Region).

○ Ba has a high demand for water resulting in its geographic range and presence on wetter sites. It does not tolerate extremely high temperatures or dry soils.

✗ Damaged advance regeneration should not be considered as future crop trees due to the probability of heart rot.

✓ Where there is sufficient advanced regeneration, overstorey removal appears to be a successful regeneration method. However, avoid the use of advanced regeneration where Ba is growing on dry sites or on rotten wood.

✗ Ba as an acceptable component in single tree selection prescriptions should be assessed based on the potential for root or butt rots that could result from harvesting damage. Advance regeneration must be assessed for long-term potential (i.e., health and vigour).

[1] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

Grand Fir and Partial Cutting

Abies grandis (Bg)

Suitable Silvicultural Systems

- ○ **Natural and Nurse-tree Shelterwoods** – Somewhat suited due to moderate shade tolerance. Note: For all overstorey harvests, take care not to damage understorey stems to avoid heart and butt rot.
- ○ **Other Forms of Shelterwood** – Suitable, as some shade is good for germination. A full removal cut maximizes the growth potential of the regeneration layers. Avoid damaging regeneration layers.
- ○ **Single Tree Selection or Irregular Shelterwoods** – Carefully plan to minimize windthrow and stem damage; consider strip or group applications.
- ✗ **Seed Tree Systems** – Not generally suitable due to potential for windthrow of seed trees (more suited than Ba).

Tolerances

- ○ **Shade** – Least shade tolerant of the true firs – low to moderate tolerance of shade. On moist sites it is less tolerant but can compete with seral species. On dry sites it grows as an understorey shade tolerant that can dominate at climax. Similar shade tolerance as Ss.
- ✗ **Growing Season Frost** – Low frost tolerance in coastal populations, moderate for interior.
- ○ **Heat/Drought** – Moderately tolerant to high temperatures and water deficits.
- ✗ **Fire** – Low tolerance due to thin bark and predominantly shallow roots.
- ✓ **Water Surplus** – Tolerant of seasonal water surpluses; common on floodplains.
- ✗ **Nutrients** – Absent on poor and very poor nutrient regimes.

Effects of Harvest Damage on Understorey Stems

- ○ Unknown – appears more susceptible to breakage above 1.3 m. If ecologically suited, post-harvest, healthy undamaged advance regeneration should be considered for well-spaced stocking for even-aged systems.
- ✗ Entry of Indian paint fungus (*Echinodontium tinctorium*) through branch stubs is a serious concern. Harvesting on heavy snowpacks can minimize damage.

Effects of Harvest Damage on Leave-trees

- ○ Bark thickness varies by location influencing the potential for serious wounding. On drier sites, thicker bark provides moderate resistance to wounding; thinner bark on moist sites offers lower resistance to wounding. Heart rot from Indian paint fungus is a common result of damage and it often manifests rapidly. Branch stubs are entry points for disease. Damaged stems should be removed where they are competing with future crop trees.

Natural Regeneration

Prolific Seed Years

- ✓ Variable – good crops approximately every 2 to 3 years west of Coast Mountain Range, less frequent in the interior.

Seed Travel Distance

- ✗ Usually within 45 to 60 m of host, up to 120 m. Large-winged seed.

Seed Distribution Method and Timing

Distributed by wind and rodents – 80% between September and the end of October. Overwinters in the forest floor.

Seed Losses

Insect damage can be considerable. Birds and small mammals consume seeds – could affect stocking in poor seed years.

Germination Needs

- ○ Germinates in the spring following dispersal (April in the open, up to August on late snow melt areas).
- ○ Best on exposed mineral soil, however, on seed tree sites, it has shown equal potential on forest floor.

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✓ Recommended ✗ Use caution ○ Informational

Grand fir (Bg)

○ Forms deep initial roots on exposed sites compared with little root growth on protected sites. Drought is a cause of mortality on some sites due to limited initial root growth.

Strategies for Enhancing Natural Regeneration

✓ Leave good seed producers (>50 years old) on exposed sites, provide shelter (i.e., leave good shade-providing trees), provide some exposed mineral soil and control brush. Manage for Bg on nutrient medium to rich sites.

Growth Potential

○ Interior growth potential ranges from highs of site index 18 to 21 m at breast height 50 years in the ICHdw (Nelson Forest Region) and up to 36 m (SI_{50}) on devil's club sites in the IDFww (Kamloops Forest Region). Coastal productivity ranges from 20 to 40 m (SI_{50}) depending on soil nutrient and moisture regime.

○ Initial growth is slow, increasing once established.

○ The greatest growth potential occurs in the open for trees 20 years old or greater.

Windthrow[1] – Snow-breakage

○ Variable resistance to windthrow depending upon location. Generally better rooted on drier sites (forms sinker or tap roots).

○ Somewhat tolerant of heavy snow loads, infrequent in areas of high snowloading.

Major Pests

✗ Highly susceptible to many common heart rots especially Indian paint fungus (*Echinodontium tinctorium*).

✗ Also susceptible to balsam woolly adelgid (*Adelges piceae*) and spruce budworm (*Choristoneura occidentalis*). Insect attacks are generally not as serious a problem as disease agents.

✗ Partial cutting may increase the potential for inoculation by root diseases such as *Armillaria ostoyae* and *Phellinus weirii* (on the coast) when present.

General

○ Bg grows mainly in mixed stands as a scattered minor component. Common associates are Fd, followed by Cw and cottonwood. Found occasionally with other true firs, red alder, and Hw.

○ Grows in the southern IDF, ICH, CDF, and drier southern CWH.

✓ Bg can capitalize on openings made in the canopy; it is therefore ecologically suited to regenerating in created gaps. Natural regeneration is suited to the shelterwood system on exposed sites.

✗ Take care to minimize stem scarring as wood quality and structural integrity could be compromised.

✗ Damaged advance regeneration should not be considered as future crop trees due to the probability of heart rot.

✗ Its acceptability in a single tree selection system will depend on minimal damage to crop trees and advance regeneration. Susceptibility to scarring will depend on bark thickness and timing of logging. Spring is the time of highest bark damage susceptibility and moist sites usually have trees with thinner bark and a higher risk of windthrow.

○ Seed tree systems can be used on non-exposed aspects; windfirmness of the Bg must be assessed.

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[1] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

Subalpine Fir and Partial Cutting

Abies lasiocarpa (Bl)

Suitable Silvicultural Systems

- ○ **Natural and Nurse-tree Shelterwoods** – May be suited due to shade tolerance, however take care not to damage to avoid future heart rots – this is true for all partial cutting regimes.
- ○ **Other Forms of Shelterwood** – Suitable with full removal cut, as some shade is good for germination. A full removal cut maximizes growth potential of the regeneration layers. Avoid damaging regeneration layers.
- ○ **Single Tree Selection or Irregular Shelterwoods** – Variations in shade tolerance of associated species will either favour Bl establishment or not. Where Bl grows with Ba, Bg, or Hm, group selection group shelterwood, or clearcutting will favour Bl. Where Bl grows with Se, shelterwood and single tree selection will favour Bl establishment.
- ✗ **Seed Tree Systems** – Not generally suitable due to risk of windthrow of seed trees unless leave-trees previously adapted to wind.

Tolerances

- ✓ **Shade** – Shade tolerant; less tolerant than Ba, more than Se, Fd, and Cw.
- ✗ **Growing Season Frost** – High tolerance to frost; can tolerate frozen soils.
- ✗ **Heat/Drought** – Seedlings are susceptible to heat girdling and drought; protection needed on hot exposed sites.
- ✗ **Fire** – Low tolerance due to thin bark and predominantly shallow roots.
- ✓ **Water Surplus** – Tolerant of flooding and seasonal water surpluses.
- ✓ **Nutrients** – Tolerant of poor nutrient status.

Effects of Harvest Damage on Understorey Stems

- ✗ Damage should be avoided to minimize rot. Harvesting with a heavy snowpack will minimize damage.

Effects of Harvest Damage on Leave-trees

- ✗ Bl is a thin-barked species that is susceptible to a range of root and butt rots. Bark damage promotes disease entry and expression. Damaging of leave-trees should be avoided.

Natural Regeneration

Prolific Seed Years

Variable – good crops approximately every 3 years.

Seed Travel Distance

Depends upon prevailing winds; most within 1 tree height with some seed dispersed up to 300 m (likely on snow).

Seed Distribution Method and Timing

Wind dispersed. Begins in September, most shed by the end of October. Overwinters in the forest floor.

Seed Losses

Insect damage can be considerable in all *Abies* species. The amount lost to birds and small mammals is unknown.

Germination Needs

- ○ Germinates in the spring following dispersal on all substrates.
- ○ Survival is highest on mineral soil, but will often survive on other substrates such as rotten wood (especially at high elevation).
- ○ Establishment and early survival are favoured by shade.
- ○ Bl can survive under an intact Se/Bl forest canopy.

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Subalpine fir (Bl)

Strategies for Enhancing Natural Regeneration

✓ Leave good seed producers (>50 years old), provide some exposed mineral soil; keep openings less than 2 tree heights wide.

Growth Potential

○ Growth potential ranges from SI 6 to 21 m at breast height 50 years (SI_{50}). Bl grows best in the ICH where it attains SI_{50} values of 21 m on mesic and wetter sites. The slowest growth was identified in the ESSF in the Prince George Forest Region, 6 m (SI_{50}).

✗ Initial Bl growth is often slow – 2.5 to 10 cm per year. Height growth slows with increasing elevation.

✗ Release is delayed by 3 to 5 years for height and 1 to 2 years for diameter, post overstorey removal.

Windthrow[1] – Snow-breakage

✗ Low resistance to windthrow as it does not form a tap root. However, in deep well-drained soils Bl can form a relatively deep lateral rooting system.

✗ Heavy partial cutting in dense stands increases susceptibility to windthrow.

✓ Tolerant of heavy snow loads.

Major Pests

✗ Highly susceptible to most common heart rots especially Indian paint fungus (*Echinodontium tinctorium*).

✗ Also susceptible to spruce budworm (*Choristoneura occidentalis*), western balsam bark beetle (*Dryocoetes confusus*).

✗ Partial cutting may increase the potential for western spruce budworm and inoculation by root rots such as *Armillaria ostoyae* and *Heterobasidion annosum* when present.

✗ Very susceptible to balsam woolly adelgid (*Adelges piceae*) but this introduced insect has not yet spread into subalpine fir stands.

General

○ Bl grows alone or in combination with a range of species: Se, Sw, Pl, Cw, Hw, Ba, Bg, Lw, Sb, Fd, and Hm.

○ Grows in montane, subalpine (alpine) sites throughout BC. It is found in the AT, submaritime MH, ESSF, MS, BWBS, SBS, IDF, upper elevation of the ICH, wetter submaritime CWH.

✓ If healthy, even decades old Bl can release after overstorey reduction. Height-growth response may take from 3 to 5 years. After overstorey reduction diameter growth increases are often significant and immediate. Diameter increases occur at all levels of the bole. Increased age increases the risk of heart rots.

✗ Due to the high susceptibility of heart rot entering through wounds created by harvesting damage, leaving Bl as a crop tree after partial cutting requires care and commitment. If left, in a uniform shelterwood or single tree selection system, care must be taken to minimize stem scarring, as wood quality and structural integrity will be compromised.

✗ In areas susceptible to attacks by spruce budworm 2 layers of Bl are not recommended.

[1] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

Western Redcedar and Partial Cutting

Thuja plicata (Cw)

Suitable Silvicultural Systems

✓ **Natural and Nurse-tree Shelterwoods** – Cw will survive and grow in an understorey position once established. Establishment under an overstorey will likely be vegetative rather than from seed. Overstorey removal may result in wood degrade due to powder worm (*Trachykele blondeli*) in susceptible areas.

○ **Other Forms of Shelterwood** – Suitable with full removal cut. In most cases shade is not necessary for germination; heavy shade may favour vegetative reproduction.

○ **Single Tree Selection or Irregular Shelterwoods** – In single tree selection Cw, can establish and grow at higher residual stocking than Fd and other less shade-tolerant species.

✗ **Seed Tree Systems** – May be suitable where Cw are windfirm.

Tolerances

✓ **Shade** – Once established very shade tolerant (often vegetative reproduction); tolerance similar to Ba.

✗ **Growing Season Frost** – Tolerance to frost ranges from very low to moderate. Cw will not survive in frost pockets or areas subject to heavy growing season frosts; this limits its geographic range.

○ **Heat/Drought** – Moderate tolerance to heat girdling. May require shelter on exposed sites. Low tolerance to drought.

✗ **Fire** – Low tolerance due to thin bark and predominantly shallow roots.

✓ **Water Surplus** – High tolerance to flooding and seasonally saturated soils resulting in rooting restricted to near the soil surface.

✓ **Nutrients** – High tolerance of nutrient deficiencies; often found on poor sites (e.g., gravel bars).

Effects of Harvest Damage on Understorey Stems

✗ Damage could result in heart rot formation. Younger stems (<60 years old) do not have the protective chemicals older Cw has. Windfirmness of advance regeneration is often poor. Advance Cw should be left in groups if possible to avoid damage and reduce windthrow. Sanitation spacing may be required a few years post harvest to reduce the area taken up by non-productive stems. Note that regeneration from vegetative layering is often infected with heart rot and should be assessed to determine their applicability as crop trees.

Effects of Harvest Damage on Leave-trees

✗ Cw has thin bark that is removed easily by impact. A range of root, butt and trunk rots attack Cw. Damage should be minimized, especially on younger (<60 year old) stems if managing using uneven-aged or long-term retention systems.

Natural Regeneration

Prolific Seed Years

Two to 4 years between good cone crops. Cw produces abundant seed; only surpassed by Hw for BC conifers.

Seed Travel Distance

Seed can be carried up to 100 m or greater if wind conditions are favourable.

Seed Distribution Method and Timing

Wind dispersed. Begins in September, most shed by the end of October. Overwinters in the forest floor. Can be shed as late as April.

Seed Losses

Losses to birds and animals are thought to be minimal. Redcedar cone midge may cause some losses.

Germination Needs

✓ Germination occurs in the spring on moist warm surfaces.

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✓ Recommended ✗ Use caution ○ Informational

Western redcedar (Cw)

✓ Survival is dependent upon a steady moisture supply and protection from extreme heat and frost.

✓ Disturbed mineral soil appears to be the best germination environment.

○ Seedlings are most susceptible to desiccation and heat stress in the first few years, thus high seedling densities are often significantly reduced during hot dry years.

○ Where minimal vegetation competition occurs, vegetative reproduction will dominate in understorey positions.

Strategies for Enhancing Natural Regeneration

✓ Disturbed mineral soil promotes germination. Limited shelter may be beneficial on hot dry sites. To promote regeneration from seed, brush control may be needed to allow light to penetrate to the forest floor.

Growth Potential

○ The productivity of Cw varies from coastal to interior conditions. Interior Cw site index ranges from 12 to 27 m at breast height at age 50 years (SI_{50}).

○ Coastal Cw site index ranges from 8 to 32 m at breast height age 50 years (SI_{50}).

○ Growth is best on fresh and moist nutrient rich sites. The poorest growth was identified on nutrient poor and drier sites.

○ Early height growth is comparable to Fd, Hw, and Ss on good sites.

Windthrow[1] – Snow-breakage

✓ Windthrow resistance depends upon the crown shape and rooting medium. Dense understorey Cw and those growing in wet soils are prone to windthrow when exposed. Older spike-top Cw have a reduced sail area and are often windfirm. Cw does not produce tap roots but does produce volumes of lateral roots making those trees growing in well-drained soils more stable than Cw growing on wetter soils.

[1] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

✓ Snow-breakage is low on coastal sites and moderate in the interior.

Major Pests

✗ Cw seedlings are a preferred browse species for deer and elk (to promote survival protection may be required).

✗ *Ceriporiopsis rivulosa*, *Perenniporia subacida* (coast) and *Phellinus weirii* cedar form (interior) fungi cause significant volume and value losses. Minimize damage when trees are to be retained for significant periods.

✗ Western redcedar borer (powder worm) (*Trachykele blondeli*) can be a wood quality problem in coastal areas below 250 m elevation. It is most common in warm sunny aspects, particularly on exposed locations such as partial cuts or near openings.

General

○ Cw grows in a range of stand types, from even-aged, single-species plantations to uneven-aged, multi-species stands. It grows with Hw, Fd, Bg, Ba, Lw, Pl, Py, Sx, Ss, and Yc. It is a climax species in the ICH and CWH zones.

○ Cw grows predominantly in the ICH and CWH zones but also grows as a minor species in a range of other zones.

✓ Due to the relatively high shade tolerance of Cw, it grows beneath a range of overstories. Partial cutting, such as single tree selection that leaves a significant overstorey, may promote Cw over less shade-tolerant species.

✓ Understorey Cw can gain significant diameter growth under partial canopy.

✗ Exercise care in choosing future crop trees as heart rot may be present in understorey stems. Stems regenerated vegetatively appear prone to infection and must be assessed.

✗ In single tree selection where Cw is being managed as a preferred component of the stand, more basal area can be retained than for Fd and Py systems. A range of 25 to 35 m^2/ha may be appropriate on good interior sites. On the coast there are no data on B level stocking, but as a starting point 30 to 35 m^2/ha may be appropriate. Open, non-brushy areas may be needed for non-vegetative reproduction to succeed.

✓ Recommended ✗ Use caution ○ Informational

Douglas-fir and Partial Cutting

Pseudotsuga menziesii (Fd)

Suitable Silvicultural Systems

- ○ **Natural and Nurse-tree Shelterwoods** – Suited to dry climates where Fd is shade tolerant (e.g., IDF and CDF). Not suited in humid climates (e.g., ICH, CWH).
- ○ **Other Forms of Shelterwoods** – On exposed sites shelterwood systems are useful for establishment. Fifteen to 30 m^2/ha will usually provide adequate shelter (depending upon slope, aspect, and live crown area of the leave-trees). Removal of the shade will facilitate full growing potential.
- ○ **Single Tree Selection or Irregular Shelterwoods** – Single tree selection is commonly used to maintain or promote uneven-aged conditions in dry-belt Fd stands. On drier, poorer sites residual basal area (RBA) between 10 to 15 m^2/ha is suitable based on local observations and Inland Empire USA data. On more productive sites, higher RBAs should be used. (Note: Only use where western spruce budworm is not a threat). Fd has a disadvantage to more shade-tolerant species (e.g., Cw, Bl, and Hw) under this regime in the ICH, SBS, MS, and CWH. Consider strip or group applications that maximize light.
- ○ **Seed Tree Systems** – Suitable where brush is not a competitive threat.

Tolerances

- ○ **Shade** – Shade tolerance ranges from tolerant in the dry IDF and CDF to intolerant in humid climates such as the CWH and ICH affecting system suitability.
- ✗ **Growing Season Frost** – Frost tolerance is very low to moderate. It is more tolerant in the interior. However, Fd will not survive in frost pockets or areas with heavy growing season frosts.
- ○ **Heat/Drought** – Moderate to high tolerance to heat girdling and drought. May require shelter on exposed sites.
- ○ **Fire** – Tolerant with age, younger stems susceptible.
- ✗ **Water Surplus** – Low tolerance to flooding or saturated soils. Roots will not survive saturated conditions, creating a plate-like rooting form.
- ○ **Nutrients** – Moderate tolerance of nutrient deficiencies, added nitrogen often provides additional growth.

Effects of Harvest Damage on Understorey Stems

- ✓ Resilience to damage appears to be related to percentage of live crown. Seedlings with serious post-harvest damage often recover to crop-tree status. Live crowns >33% provide a greater than 50% chance of recovery. Live crowns >66% have better than 75% chance of recovery. Leaders broken off will be superseded by an alternate with little growth reduction.

Effects of Harvest Damage on Leave-trees

- ○ Thick bark and the ability to quickly cover the wound with resin makes older stems resistant to decay entry through wounds. Spring logging is the most sensitive period for wounding. Wounds can result in reduced vigour leaving trees more susceptible to insect attack and disease, potentially reducing wood quality and value. Stressed leave-trees are susceptible to Douglas-fir beetle. Leave-trees also die for no primary reason – post-logging syndrome (check local history to determine severity).

Natural Regeneration

Prolific Seed Years

- ✓ Two to 10 years – between good crops, often one crop failure and light or medium crops.

Seed Travel Distance

- ✓ Seed can be carried over 200 m if wind conditions are favourable.

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✓ Recommended ✗ Use caution ○ Informational

Douglas-fir (Fd)

Seed Distribution Method and Timing

Wind dispersed in late summer, into winter, and next spring. Most deposited by late October.

Seed Production

Collectable quantities found on stems 20 to 25 years old. Older trees are more prolific producers with open grown most prolific. Old growth can produce 20 to 30 times more seed than 50 to 100 year old.

Seed Losses

During moderate to low seed production years, predation and pests may reduce seed numbers significantly.

Germination Needs

- ○ Survival is dependent upon a steady moisture supply and protection from extreme heat (on steep southerly aspects especially in hot, dry subzones).
- ○ Mineral soil or mixed mineral and forest floor are the ideal germination environment.
- ○ Seedlings are most susceptible to desiccation and heat stress in the first few years, thus high seedling densities are often significantly reduced during hot dry years.

Strategies for Enhancing Natural Regeneration

- ✓ Leave older trees with full crowns as seed producers. Create exposed mineral soil to promote germination and establishment. Leave shade trees in hot dry portions of its range (e.g., flat to S and SW aspects).
- ✗ In humid climates, brush competition often will limit survival. Burning can reduce competition and promote natural Fd regen.

Windthrow[1] – Snow-breakage

- ✓ Considered relatively windfirm. Resistance depends on topographic site and stand characteristics. Trees infected by *Phellinus weirii* are prone to windthrow.
- ✗ Snow-breakage is common in thinned second growth stands due to thin, tall, small-crowned stems. Snow-breakage is a natural thinning agent in dense regeneration patches of interior Fd. Snow-breakage can be significant in higher elevations.

Major Pests

- ✗ Root diseases (e.g., *Armillaria ostoyae* and *Phellinus weirii*) may limit options for partial cutting (mesic ecosystems are higher hazard). When root rots are found at high levels, partial cutting should be reconsidered. Inoculum removal (stumping) may be used to reduce hazard and improve site productivity. At lower levels, consider alternative species with Fd.
- ✗ Western spruce budworm (*Choristoneura occidentalis*) is a serious pest of Fd, more so than it is to spruce. Dense thickets of young Fd with mature Fd close by are very susceptible to infestation. Avoid layered stands or multilayer stands in areas of high budworm potential. Opt for open vigorous stands, where age-classes are clumped and spatially separated.
- ✗ Douglas-fir beetle (*Dendroctonus pseudotsugae*) breeds in down or damaged trees and can kill mature or overmature trees. It can also attack stressed leave-trees. Contact the regional entomologist.
- ✗ Douglas-fir dwarf mistletoe is a potential problem.

General

- ○ Fd seedlings and saplings can release from competing shade and escape snow-breakage and sunscald if they have not been suppressed too severely or for too long. Intermediate thinnings to maintain vigour and prepare stands for future removal cuts may be needed.
- ○ Shelterwood systems are appropriate on south or west aspects where a continuous full-height canopy is not required to meet landscape objectives (i.e., remove most overstorey once regeneration is established to promote understorey growth).

[1] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

Mountain Hemlock and Partial Cutting

Tsuga mertensiana (Hm)

Suitable Silvicultural Systems[1]

✓ **Natural and Nurse-tree Shelterwoods** – Suitable when adequate advance regeneration is established.

✓ **Other Forms of Shelterwood** – Uniform, strip, and group are all appropriate in areas where snowpacks limit growing season length, snow creep on steep slopes, frost pockets, and wind exposed sites. More information is needed on the success of ingress versus advance regeneration.

✓ **Single Tree Selection or Irregular Shelterwood** – Both appear to be appropriate, especially in areas as described above with advance regeneration present.

✗ **Seed Tree Systems** – Not advised unless planted.

Tolerances

✓ **Shade** – Moderately to highly shade tolerant. Hw, Ba, and Yc are more tolerant.

○ **Growing Season Frost** – Tolerance to frost is moderate. Snow needed to protect from winter desiccation.

✗ **Heat/Drought** – Low tolerance to heat girdling. Relatively low tolerance to drought. However, does establish on deep pumice soils.

✗ **Fire** – N/A; low incidence in the zones where Hm grows.

✓ **Water Surplus** – Moderate tolerance to flooding and seasonally saturated soils. Grows on elevated microsites.

✓ **Nutrients** – High tolerance of nutrient deficiencies, often found on poor sites.

[1] Leave-trees should be mistletoe free. Partial shading can benefit early seedling growth, with the best growth in the open once established (advance regeneration will release if healthy). Hm is adapted to a clumpy distribution.

Effects of Harvest Damage on Understorey Stems

✗ Unknown. It is flexible making it less prone to breakage when young.

Effects of Harvest Damage on Leave-trees

✗ Little is known about the specific risk to residual Hm although it is known to be susceptible to many of the same wound invaders and heart rots as Hw.

Natural Regeneration

Prolific Seed Years

✓ Three or more years between large cone crops.

Seed Travel Distance

Mostly within 500 m of the parent tree.

Seed Distribution Method and Timing

Wind distributed in the fall and early winter.

Seed Production

More than 30 years for collectable amounts; continues producing seed in 250+ year trees.

Seed Losses

✗ Minimal.

Germination Needs

✓ Moist environments – no best substrate has been identified.

○ In areas of high snowpack, potential for snow creep, frost pockets or on exposed sites, shelter is needed for establishment. Shelter can be from overstorey trees and in some cases ericaceous shrubs.

○ Germinates on less productive sites; productive sites often have established brush complexes.

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Mountain hemlock (Hm)

Strategies for Enhancing Natural Regeneration

✗ Leave-tree islands for seedling protection, and snow management.

✗ Leave healthy windfirm patches for a seed source. Individual trees will be prone to windthrow due to shallow rooting.

Growth Potential

○ Hm grows predominantly in the MH zone and to a lesser extent in the CWH and some ESSF zones.

○ Hm site index at breast height 50 years ranges from 8 to 16 m from very limited data.

○ Early height growth is generally slow.

Windthrow[2] – Snow-breakage

✗ In general, Hm has a low resistance to windthrow due to its shallow rooting pattern (roots are often found only in the forest floor).

✓ Snow-breakage is low due to high flexibility and crown shape.

[2] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

Major Pests

✓ Few insect pests.

✗ Hm is very susceptible to hemlock dwarf mistletoe (*Arceuthobium tsugense*).

✗ Hm is susceptible to several root diseases.

✗ Hm is susceptible to heart rots like Indian paint fungus (*Echinodontium tinctorium*) and wound invaders like *Fomitopsis pinicola* (red belt) and *Stereum sanguinoletum* (red heart rot). Damage to leave-trees decreases vigour and increases the likelihood of decay.

General

○ In areas of high snow accumulation, advance snow creep, or on exposed sites, partial cutting to maintain tree islands may be needed to promote advance regeneration.

○ If healthy, advance regeneration can release well. Manage for Hm if present.

Western Hemlock and Partial Cutting

Tsuga heterophylla (Hw)

Suitable Silvicultural Systems

✓ **Natural and Nurse-tree Shelterwoods** – Suitable when adequate advance regeneration is established.

○ **Other Forms of Shelterwood** – An option, however damage-induced decay, dwarf mistletoe in potential leave-trees, and windthrow risk may limit leave-tree distribution options to groups or strips. Leave-trees should be mistletoe free.

✗ **Single Tree Selection or Irregular Shelterwoods** – Carefully plan to minimize windthrow and stem damage, consider strip or group applications.

✗ **Seed Tree Systems** – Poor due to risk of windthrow of seed trees.

Tolerances

✓ **Shade** – Shade tolerant. Similar to Ba and Cw.

✗ **Frost** – Tolerance to frost ranges from very low to low. More tolerant in the interior than on the coast. However, Hw will not survive in frost pockets or areas subject to heavy growing season frosts, limiting its geographic range.

✗ **Heat/Drought** – Low tolerance to heat girdling. Requires shelter on exposed sites. Low tolerance to drought. Top die back is common with prolonged drought. Summer drought limits geographic extent.

✗ **Fire** – Low tolerance due to thin bark and predominantly shallow roots.

✓ **Water Surplus** – Moderate tolerance to flooding and seasonally saturated soils. On wet sites it establishes and grows on elevated microsites (e.g., nurse logs).

✓ **Nutrients** – High tolerance of nutrient deficiencies, often found on poor sites. Variable in its response to N fertilization.

Effects of Harvest Damage on Understorey Stems

○ If advance regeneration is less than 2 m and healthy at the time of release, there is a good chance it will be acceptable unless it is very old or regenerated by layering.

✗ Hw understorey stems have thin, easily damaged bark. Wounding of advance regeneration will promote the incidence of butt and root rots.

Effects of Harvest Damage on Leave-trees

✗ Hw is a thin-barked species, susceptible to a broad range of root and butt rots. Wounding promotes entry and expression. Avoid wounding of leave-trees.

Natural Regeneration

Prolific Seed Years

✓ Three to 4 years between good cone crops. Hw produces abundant seed.

Seed Travel Distance

✓ Seed can be carried up to 1 km or greater if wind conditions are favourable.

Seed Distribution Method and Timing

Seed is disseminated by wind in the late summer until spring if conditions are wet.

Seed Production

Collectable quantities are found on stems 25 to 30 years of age and older.

Seed Losses

✓ Minimal.

Germination Needs

○ Provided there is adequate moisture and protection from extreme heat and frost, germination and survival occurs successfully on a range of substrates.

○ Decaying logs and rotten wood are preferred substrates in brushy areas and beneath forested canopies. In warm, dry, more exposed environments, mineral soil seedbeds are preferred as they retain moisture longer than forest floor.

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✓ Recommended ✗ Use caution ○ Informational

Western hemlock (Hw)

Strategies for Enhancing Natural Regeneration

✓ Provide some exposed mineral soil and control brush.

Growth Potential

○ The productivity of Hw varies from coastal to interior conditions. Interior Hw site index at breast height 50 years (SI_{50}) ranges from 12 to 21 m – the most common is 15 to 18 m.

○ Coastal Hw site index ranges from 8 to 32 m.

○ Hw shows its best growth in lower elevation CWH subzones on fresh to very moist nutrient medium to rich sites.

○ Early height growth is variable and can be slow (e.g., ~10 cm/yr), once established 60+ cm/yr is common.

Windthrow[1] – Snow-breakage

✗ In general Hw is not considered windfirm due its shallow rooting and predisposition to growing in dense stands on organic substrates. Hw does not produce a tap root. To minimize windthrow, leave trees in groups or strips, rather than dispersed.

○ Open, dispersed leave-trees require deep well-drained soils and little exposure to minimize windthrow. Windsnap may be more common than windthrow at higher elevations.

✓ Snow-breakage is low in coastal sites and moderate in the interior.

[1] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

Major Pests

✗ Heart rots (e.g., *Echinodontium tinctorium, Fomitopsis pinicola,* and *Phellinus pini)* reduce wood quality and may result in stem breakage. These rots enter rapidly through stem wounds or branch stubs. Wood quality can be dramatically reduced over a short period.

✗ Hw is also susceptible to the common root diseases (e.g., *Armillaria ostoyae, Phellinus weirii* and *Heterobasidion annosum).*

✗ Dwarf mistletoe (*Arceuthobium tsugense*) increases mortality, reduces growth and provides entry points for fungi. It is common in old coastal Hw stands. Remove or girdle infected overstorey leave-trees soon after regeneration establishment to control spread.

✗ If in areas of historical outbreak, Hw can be significantly impacted by insect defoliators, western blackheaded budworm (*Acleris gloverana*) and western hemlock looper (*Lambdina fiscellaria lugubrosa*).

General

✓ Hw is capable of establishment and growth under an overstorey. Its growth is retarded in proportion to the amount of shade it is under. Release may be related to the time spent beneath the overstorey, as new regeneration has often surpassed the growth of smaller and stunted older 'advanced' regeneration. Healthy, vigorous intermediate stems respond well to release.

○ Because Hw wounds easily, often resulting in heart rot, any form of partial cutting with a timber production objective should aim to minimize wounding.

○ In single tree selection, where Hw is being managed as a preferred component of the stand, more basal area can be retained than for Fd and Py systems. A range of 25 to 35 m^2/ha may be appropriate on good growing sites in the interior. On the coast, there are no data but as a starting point 25 to 35 m^2/ha may be appropriate.

Western Larch and Partial Cutting

Larix occidentalis (Lw)

Suitable Silvicultural Systems

✗ **Natural and Nurse-tree Shelterwoods** – Not suited as Lw is highly shade intolerant.

✗ **Other Forms of Shelterwoods** – Open shelterwoods may be suitable if overstorey trees are removed soon after establishment.

✗ **Single Tree Selection or Irregular Shelterwoods** – Not suited to Lw unless extremely open conditions are created and maintained (e.g., strips oriented to maximize light).

✓ **Seed Tree Systems** – Well suited to the seed tree system where Lw produces viable seed.

Tolerances

✗ **Shade** – Highly shade intolerant (the most shade intolerant conifer in the northern Rocky Mountains).

✓ **Growing Season Frost** – Moderate to high tolerance to frost; similar to Py.

✗ **Heat/Drought** – Susceptible to lethal stem girdling on south- and west-facing slopes at lower elevations. Moderately to not tolerant of extremely dry conditions; infrequent on very dry sites.

✓ **Fire** – Older trees are highly tolerant due to thick bark and deep roots.

✗ **Water Surplus** – Does not grow in saturated soils.

○ **Nutrients** – Moderate tolerance of nutrient deficiencies.

Effects of Harvest Damage on Understorey Stems

✓ Removal of seed trees may damage established young Lw, where possible seed trees should be retained as long-term seed sources and as future wildlife trees.

Effects of Harvest Damage on Leave-trees

✗ While Lw is a thick-barked species, it is very susceptible to a range of root and butt rots. Harvest damage of stems promotes entry and expression. Avoid damage to leave-trees. Lw is a common host for the wound invader *Fomitopsis officinalis* (brown trunk rot).

Natural Regeneration

Prolific Seed Years

✗ One to 10 years (highly variable, check local periodicity).

Seed Travel Distance

✓ Variable, up to 100 m.

Seed Distribution Method and Timing

Wind in late summer; some are dispersed throughout the winter into the next summer.

Seed Production

Minimum age 25 years for collectible amounts. Cone numbers increase with crown size.

Seed Losses

✓ No major cone or seed pests.

Germination Needs

✓ Burned sites with exposed mineral soil provide the greatest chance of survival and growth potential.

✗ Lw will germinate on the forest floor. Least desirable medium, as lethal temperatures occur earlier in the season and more frequently than on other mediums.

○ Root growth is affected by shading; shaded sites have the least root growth often resulting in drought-induced death.

○ Deep shade (stumps, logs) may be useful for early survival on steep south or west slopes to minimize heat girdling.

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✓ Recommended ✗ Use caution ○ Informational

Western larch (Lw)

Strategies for Enhancing Natural Regeneration

✓ Leave good seed trees (i.e., those with full crowns). Burning creates good seedbed conditions. Where burning is not suitable, prepare site mechanically (e.g., disc trenching) to provide exposed mineral soil.

Growth Potential

○ Grows in lower southeastern ESSF, MS, southeastern portions of the IDF and ICH, and in portions of the PP.

○ Site index at breast height 50 years and ranges from 12 to 27 m. Lw grows best in the ICH where it attains SI_{50} values of 27 m on fresh nutrient-rich sites. The poorest growth identified in the PP, IDF, and ESSF on drier sites (SI_{50} 12–15 m).

✗ U.S. studies have shown that very high densities result in height repression similar to that found in Pl.

○ Slow initial height growth (e.g., 5 cm of height growth for the first 3 years), once established, rates of >50 cm/yr are common.

Windthrow[1] – Snow-breakage

✓ High resistance to windthrow due to extensive rooting network when open grown. Dense stands may be prone to wind snap and extreme bending when opened up (e.g., stands with ht/diam ratios of >100). Windthrown trees may exhibit root rot.

✓ Low risk of snow-breakage due to the deciduous nature of Lw.

[1] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

Major Pests

✗ Larch dwarf mistletoe (*Arceuthobium laricis*) is a serious parasite. Where infection levels are high, overstorey trees should be removed once regeneration is established.

✗ Larch casebearer (*Coleophora laricella*), needle cast *(Hypordemella laricis)* and western spruce budworm may create local problems.

✓ Established Lw has been found to be relatively resistant to *Armillaria ostoyae*, but juvenile Lw is quite susceptible.

General

○ Lw is highly shade intolerant once established. Lw is well adapted to the seed tree system. Seed trees should have full crowns (minimum 20%; 35 to 50% is recommended), >35 cm dbh and be free of mistletoe. Distribution of one seed tree every tree length provides good seed cover and insurance against fire or other losses.

○ Seed trees often increase diameter growth after the regeneration harvest.

○ If Lw is desired in the next stand, plan to plant as seed crops are sporadic.

○ Lw is susceptible to decay if wounded.

Lodgepole Pine and Partial Cutting

Pinus contorta var. *latifolia* (Pl)

Suitable Silvicultural Systems

✗ **Natural and Nurse-tree Shelterwoods** – Generally not suited due to shade intolerance.

○ **Other Forms of Shelterwood** – Low-density shelterwoods should not hinder Pl growth significantly. Shelterwood overstories need to be removed to promote Pl growth.

✗ **Single Tree Selection or Group Selection** – Not suited due to shade intolerance. Group selection may be an option if group openings are oriented to provide maximum light.

✗ **Seed Tree Systems** – Not suited as Pl cones are primarily serotinous and remain on the tree. Often younger trees (e.g., <20 years old) have cones that open on the trees. Serotony varies across its range and should be assessed locally.

Tolerances

✗ **Shade** – Shade intolerant (similar to Lw; more intolerant than Py).

✓ **Growing Season Frost** – High tolerance to frost, in most cases the highest tolerance of BC conifer species. However may vary by location.

○ **Heat/Drought** – Moderate tolerance to heat girdling – by 2 to 4 weeks seedlings can withstand temperatures that would kill spruce. Tolerant of drought once established. Drought at establishment results in high mortality. To minimize the effect of drought mixed mineral/organic or mineral soil provides optimal establishment potential.

✗ **Fire** – Low tolerance due to thin bark.

✓ **Water Surplus** – Tolerant of water surpluses, grows in areas with fluctuating water table.

✓ **Nutrients** – Tolerant of nutrient deficiencies, present over the range of nutrient regimes.

Effects of Harvest Damage on Understorey Stems

○ While Pl can survive in understorey positions for a period of time, it is not suited to growing beneath a canopy. In most cases, there will be no Pl advance regeneration. Where there is advance regeneration (in the driest portion of its range) it may be of low vigour and susceptible to snow-breakage due to the poor height to diameter ratio. Additional damage through harvesting will further weaken the remaining stems increasing their susceptibility to a range of pests that thrive on Pl. Check locally for acceptability of Pl advance regeneration.

Effects of Harvest Damage on Leave-trees

○ While Pl is a thin-barked species it reduces infection risk by producing copious resin flow over wounded areas. Studies have shown that less than 10% of injuries had associated decay. Damage can result in wood quality reductions impacting value.

Natural Regeneration

Prolific Seed Years

✓ Every 3 years with consistent crops.

Seed Travel Distance

Near the cone – Pl over most areas of BC has serotinous cones (i.e., they open with heat usually when the cones are on or near the ground).

Seed Distribution Method and Timing

Wind distributes seed once released from the cone. This usually occurs in late spring or early summer when temperatures are high enough to open the cones.

Seed Production

Seed production begins early. Collectable amounts are available from 20 year old stands. Seed availability depends upon cone distribution. Assessment procedures are available from the MoF.

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✓ Recommended ✗ Use caution ○ Informational

Lodgepole pine (Pl)

Seed Losses

✓ Insect damage to Pl cones tends to be minimal. Without a damaging agent, interior Pl has filled seeds only in the top 1/3 to 1/2 of the cone.

Germination Needs

○ The best conditions for germination include full sunlight on mineral soil or disturbed forest floor, free of competition.

○ A partial overstorey usually reduces germination and survival.

○ Pl roots grow slowly requiring early moisture.

○ When conditions are suitable Pl often germinates at very high densities.

Strategies for Enhancing Natural Regeneration

✓ Ensure good cone coverage and suitable germination substrate (mineral or mixed mineral soils).

Growth Potential

○ Site index at breast height 50 years ranges from 6 to 27 m. Pl data show the highest site index in the ICHmw2 variant where it can attain SI_{50} values of 27 m on wetter than mesic sites. The poorest growth is in the Prince George BWBS dry cool variants on nutrient poor and drier sites.

○ Early height growth can be greater than 50 cm/yr once established.

○ Grows well as an even-aged stand over a range of densities. High densities can result in height repression and reduced volume.

Windthrow[1] – Snow-breakage

○ Variable resistance to windthrow depending on location. Generally better rooted on non-root restricting, well-drained sites (forms tap roots). Often Pl will be prone to windthrow if dense stands are opened up.

✗ Snow-breakage can be a concern in high snowpack areas.

[1] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

Major Pests

✗ Mountain pine beetle *(Dendroctonus ponderosa)* is the most serious insect enemy of mature Pl. Partial cutting to increase individual tree vigour, change microsite conditions and thereby reduce attack, is termed beetle proofing.

✗ Lodgepole pine dwarf mistletoe *(Arceuthobium americanum)* is common within Pl range. Regeneration is susceptible once branches are thicker than 1 cm. Do not leave infected stems post harvest.

✗ Pl is susceptible to Armillaria, Tomentosus, and Blackstain root diseases.

✗ Juvenile Pl is susceptible to stem rusts, and Pl terminal weevil.

○ Rusts are likely the largest mortality agent in juvenile stands.

- Western gall rust (*Endocronartium harknessii*) – occurs in stands of any density; occasionally causes mortality but reduces wood quality and can weaken stems.
- Elytroderma disease and pine needlecast can cause growth reduction.

✗ *Ips* can be a major problem in commercial thinning or in the aftermath of mountain pine beetle infestation.

○ Remove trees with Atropellis canker, stalactiform, or western gall rust during partial cuts.

General

○ Pl grows in many of BC's biogeoclimatic zones: MS, BWBS, SBS, SBPS, IDF, ICH; with a coastal variety (*Pinus contorta* var. *contorta*) found in the CDF, CWH, and MH.

○ Pl grows mainly as pure even-aged stands (fire or harvest originated) or in combination with other species. Pl may be a seral species with shade-tolerant species beneath (nurse-tree shelterwood).

○ Pl, like Lw, has early rapid height growth.

○ If Pl is desired post harvest, partial cuts in pure stands must promote open conditions. Set clear objectives for partial cuts.

○ Uneven-aged systems are not suited to the maintenance of Pl in the stand.

✓ Recommended ✗ Use caution ○ Informational

Western White Pine and Partial Cutting

Pinus monticola (Pw)

Suitable Silvicultural Systems

✗ **Natural and Nurse-tree Shelterwoods** – Not suited as associated species are more shade tolerant.

○ **Other Forms of Shelterwood** – Pw germination and establishment can benefit from shade on exposed southern aspects (shelterwood systems, with planned overstorey removal). On less harsh sites, no shade is needed for establishment (clearcut, seed tree, and retention systems).

○ **Single Tree or Group Selection** – Pw is at a disadvantage to more shade-tolerant species (e.g., Cw and Hw) under single tree selection regimes. Group selection can be prescribed to promote Pw establishment.

○ **Seed Tree Systems** – Could be used where rust-free seed trees are present. Once established, Pw grows best in open conditions on all sites.

○ Rapid growth of Pw often results in a somewhat two-storied stand with other species on-site.

Tolerances

✓ **Shade** – Moderately shade tolerant (similar to Bg). Grows best in full sunlight.

✓ **Growing Season Frost** – Moderate to high tolerance to frost. More tolerant in the interior than on the coast.

✗ **Heat/Drought** – Moderate to low tolerance to heat girdling. High surface temperatures are a major threat to survival on exposed sites. Not tolerant of drought conditions. Found on slightly dry and moister ecosystems.

○ **Fire** – Intermediate in fire resistance. Pw depends on fire or harvesting for creating conditions for successful regeneration.

✓ **Water Surplus** – Tolerant of water surpluses.

✗ **Nutrients** – Low tolerance of nutrient deficiencies; found predominantly on richer sites.

Effects of Harvest Damage on Understorey Stems

○ The branching pattern of Pw makes it susceptible to breakage from falling trees. May be less susceptible when under 1 m in height.

Effects of Harvest Damage on Leave-trees

○ Wounding can result in increased levels of heart rot. Pw is classed with Fd as being tolerant to damage-caused rot. Stressed trees are more susceptible to mountain pine beetle and root diseases such as *Armillaria ostoyae*.

Natural Regeneration

Prolific Seed Years

Every 3 to 7 years.

Seed Travel Distance

Most seed falls within 100 m of the parent.

Seed Distribution Method and Timing

Primarily wind distributed in the late summer. Squirrels, mice, and birds can also contribute to dispersal. Most of the seed is spread by the end of October.

Seed Production

Forty cones per tree are considered a good crop. Trees may produce cones from 10 years old. Most seed is produced by vigorous dominant or codominant trees over 70 years of age.

Seed Losses

✗ Can be significant. Seed and germinants can be affected by diseases, insects, rodents, and birds.

Germination Needs

○ The best conditions for germination and survival are found on mineral soil, even though forest floor may have many more stored seeds.

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✓ Recommended ✗ Use caution ○ Informational

Western white pine (Pw)

- ○ Germination occurs in the spring usually on soils wet to field capacity from melting snow.
- ○ Seedling survival is favoured by partial shade on severe to moderately severe sites.
- ○ On north slopes or less severe sites no shade is needed.

Strategies for Enhancing Natural Regeneration

- ○ Due to the potential for white pine blister rust, rust-free seed trees should be favoured. Exposed mineral soil will promote survival. On harsh (steep southwestern facing) sites some shelter may be useful for successful establishment. Pruning of lower limbs may be required to reduce the risk of blister rust infection. Local restrictions on acceptability of Pw regeneration may apply.

Growth Potential

- ○ Site index at breast height 50 years ranges from 18 to 27 m. Pw grows best in wetter/ richer sites of the ICH zone. The poorest growth is on nutrient-poor and drier sites in the ESSF, SBS, and ICH.
- ○ Early height growth can be relatively slow, taking up to 10 years to reach 2 m. Once established, height increments of 50 cm to 100 cm are common on good sites.

Windthrow[1] – Snow-breakage

- ✓ Moderate resistance to windthrow. Most of the rooting system is located in the top 30 cm of the soil profile. Most of the rooting is horizontal with few vertical (tap) roots. Mature roots can spread 8 m from the bole.
- ✓ Tolerant of heavy snow loads; snow-breakage is uncommon.

[1] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

Major Pests

- ✗ White pine blister rust *(Cronartium ribicola)* is the greatest threat to Pw. Many areas have been partially cut to remove infected stems. Regeneration, however, is often affected. Check local guidelines on the acceptability of Pw regeneration.
- ✗ Mountain pine beetle *(Dendroctonus ponderosae)* attacks mature Pw, often those weakened by blister rust.
- ○ Pw is tolerant of laminated root rot *(Phellinus weirii)*, but is susceptible to Armillaria root rot *(Armillaria ostoyae)*.
- ✗ Bears cause basal scarring that can lead to heart rots (as can logging damage). Pw is susceptible to the heart rot *Phellinus pini*, among others.

General

- ○ Pw grows mainly in mixed-species, even-aged stands. It grows predominantly in the ICH but also grows in the CWH, IDF, MS, lower southern ESSF, and MH.
- ○ Pw grows with the following conifers: Ba, Bg, Ba, Lw, Se, Fd, Cw, and Hw.
- ✓ Early Pw height growth from the literature is reported as less than Pl and Lw. However, isolated sapling-sized Pw are often the largest individuals in naturally regenerated ICH blocks in the southern interior.
- ○ White pine is best suited to early successional conditions. Once established it grows best in full light conditions. Partial cuts that provide such a situation will favour it. Small patch and single tree cuts favour its more shade-tolerant associates.
- ○ It could be considered intermediate in its growth response to release between the poor response of Lw and Pl and the more suited shade tolerant Bg, Hw, and Cw.

Ponderosa Pine and Partial Cutting

Pinus ponderosa (Py)

Suitable Silvicultural Systems

✗ **Natural and Nurse-tree Shelterwoods** – Not suited as associate species are more shade tolerant (e.g., Fd).

○ **Other Forms of Shelterwood** – Suitable, as some shade can benefit germination on severe sites. Full removal cut maximizes growth of understorey stems.

○ **Single Tree Selection or Irregular Shelterwoods** – Can be appropriate where growing conditions are kept open to allow for considerable direct sunlight. Leave no more than 8 to 12 m^2/ha overstorey to promote growth of understorey stems.

✗ **Seed Tree Systems** – Are limited by seed produced finding appropriate microsites near the host tree. However, leaving trees at seed tree densities to promote structural diversity is feasible.

Tolerances

✗ **Shade** – Moderately to highly shade intolerant (more tolerant than Lw but less so than Bg and Pw).

○ **Growing Season Frost** – Moderate tolerance to frost, some overhead protection likely useful for establishment.

✓ **Heat/Drought** – Highly tolerant of dry conditions once established.

✓ **Fire** – Tolerant due to thick bark and deep roots (more tolerant than Fd and true firs).

○ **Water Surplus** – Can tolerate short-term saturated conditions.

✗ **Nutrients** – Absent from acidic and nutrient very poor sites.

Effects of Harvest Damage on Understorey Stems

✗ Branches are brittle and will break easily.

✗ Broken leaders can lead to multiple tops reducing wood quality – avoid damage to regeneration.

Effects of Harvest Damage on Leave-trees

✗ Thick bark and copious resin flow makes it relatively resilient to damage.

Natural Regeneration

Prolific Seed Years

Variable – medium crops every 2 to 3 years; good on average every 8 years.

Seed Travel Distance

Usually within 40 m of host, up to approximately 120 m.

Distribution Method and Timing

Wind in late summer, sometimes into winter.

Seed Production

Minimum age 7 years. Most viable seed from trees 60 to 160 years old; seed produced on trees up to at least 350 years.

Seed Losses

Insect damage can be considerable. Many birds and small mammals consume seeds – could affect stocking in poor seed years.

Germination Needs

○ Germination and survival depend upon abundant seed finding suitable germination medium.

○ Wetter than average spring favour germination and survival.

○ Some shade, as Py is susceptible to heat girdling when young (thin bark).

Strategies for Enhancing natural Regeneration

✓ Leave good seed producers (60 to 160 years old) to provide shelter (i.e., leave good shade providing trees); underburn where possible for Py. Manage for Py on moderate-textured soils. Finer textured soils favour grass species. When Fd is present you may need to plant Py as Fd may dominate the site.

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✓ Recommended ✗ Use caution ○ Informational

Ponderosa pine (Py)

Growth Potential

- ○ Site index at breast height age 50 years ranges from 6 to 24 m with an average of 15 to 18 m.
- ○ SI_{50} data indicate the best growth is found in the IDFww transitional subzone between the coast and interior on fresh nutrient very rich sites (demands high levels of nitrates, magnesium, calcium, and potassium).
- ○ Once established height growth can be rapid.
- ○ Py forms tap roots. Greatest root development is found in medium-textured soils, poorest in fine-textured soils. Within months of germination tap roots can extend 50 cm in moist, loose soils. Maximum rooting depth is approximately 2 m, usually within 1 m. In open stands roots can extend over 40 m from the bole.

Windthrow[1] – Snow-breakage

- ✓ High resistance to windthrow due to extensive rooting network when open grown. Trees growing in dense stands may be prone to snap when opened up.
- ✗ Heavy snowpacks can cause significant damage; sapling clumps are especially vulnerable.

Major Pests

- ○ Rusts are likely the largest mortality agent in juvenile stands.
  - ~ *Atropellis piniphila* and Western gall rust (*Endocronartium harknessii*) – cause minimal mortality but reduce wood quality and, if on the stem, serve as a weak point for stem breakage.
- ✗ Py is susceptible to *Armillaria ostoyae*.
- ✗ Elytroderma disease (*Elytroderma deformans*) can cause broom formation. Heavy infections can cause severe growth reduction.
- ✗ Mountain pine beetle (*Dendroctonus ponderosa*) can kill Py. Larger, less vigorous trees are most susceptible.
- ✗ *Dendroctonus valens* will attack stressed trees.
- ✗ Pine needle sheath miner can be a problem in understorey growth in Okanagan areas.
- ✓ Root and butt rots are not considered a significant problem, with the exception of *Phaeolus schweinitzii* and *Phellinus pini*.

General

- ○ Grows in PP, southern ICH, IDF, MS, and lower southern ESSF zones.
- ○ Py is predominantly shade intolerant, therefore growth will be reduced in understorey positions. It can release when opened up; vigour will dictate the speed of release. For Py to grow under a canopy, a minimum of 40% sunlight is needed.
- ○ Natural disturbances of small frequent ground fires create an uneven-aged structure (small groups of even-aged cohorts). Fire exclusion favours Fdi, which has become dominant in many formally Py dominated ecosystems.
- ○ Care must be taken not to damage advance regeneration as deformities can occur.
- ○ Mature trees do not scar easily but will lose bark if scuffed in the spring. Protect where possible.
- ○ Natural regeneration is sporadic – it depends on good seed years and moist spring conditions. Planting is an option to ensure adequate stocking levels.

[1] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

Sitka Spruce and Partial Cutting

Picea sitchensis (Ss)

Suitable Silvicultural Systems

✓ **Natural and Nurse-tree Shelterwoods** – Nurse-tree shelterwoods under red alder and/or cottonwood are a recommended option for floodplain sites.

○ **Other Forms of Shelterwood** – Suitable, as some shade is good for germination. Full removal cut maximizes growth of understorey stems.

✗ **Single Tree Selection or Irregular Shelterwoods** – Must carefully plan to minimize windthrow and stem damage. Strongly consider strip or group applications.

✗ **Seed Tree Systems** – Not suited to this system as its associate Hw will dominate the regeneration.

Tolerances

○ **Shade** – Low to moderately shade tolerant (less tolerant than Hw, its most common associate); can survive under broadleaf cover (i.e., open nurse-tree shelterwoods).

✗ **Growing Season Frost** – Low tolerance to frost. Frost is not usually a problem in hypermaritime climates where it grows.

✗ **Heat/Drought** – Little information on susceptibility to heat girdling – likely not an issue in its coastal environment. Not tolerant of drought – not found in water-deficient sites.

✗ **Fire** – Low tolerance due to thin bark and predominantly shallow roots.

✓ **Water Surplus** – Grows on floodplains and in areas of seasonally saturated soils (roots will be at or near the soil surface). Prolonged flooding will cause mortality due to lack of aeration.

✗ **Nutrients** – Low tolerance of nutrient deficiencies; absent on very poor sites, rare on poor sites.

Effects of Harvest Damage on Understorey Stems

○ No available information.

Effects of Harvest Damage on Leave-trees

✗ Wounding can lead to heart and butt rots.

Natural Regeneration

Prolific Seed Years

Every 3 to 5 years.

Seed Travel Distance

Light seeds can travel far (e.g., up to 800 m from large trees on high ground).

Seed Distribution Method and Timing

Wind – dissemination begins in October in periods of dry weather.

Seed Production

Twenty-five to 40 years old for collectable amounts. High cone numbers are common in good cone years.

Seed Losses

Not likely a problem in good seed years.

Germination Needs

○ In many cases Hw will outcompete Ss in low light conditions resulting in Hw dominated stands.

○ Mixed mineral and organic seedbeds provide the best germination medium in light shade or small gaps.

○ Rotten wood may be the only suitable substrate in areas with high water tables, frequent flooding, and severe brush competition.

○ Brush competition may limit survival.

Strategies for Enhancing Natural Regeneration

○ Create small openings to minimize blowdown of residual trees. Create exposed mineral soil seedbeds on partially shaded sites. Accept that Hw will likely dominate with scattered Ss. Plant Ss if a component is desired.

Forest Practices Branch
Ministry of Forests

✓ Recommended ✗ Use caution ○ Informational

Sitka spruce (Ss)

Growth Potential

- ○ Site index at breast height 50 years ranges from 12 to 36 m. Ss grows best in the CWHds and wh variants where it attains SI_{50} values of 36 m on moist to wet rich to very rich sites.
- ○ Height growth of <10 cm/yr for the first 2 years followed by accelerated growth can be expected (e.g., >50 cm/yr).

Windthrow[1] – Snow-breakage

- ○ Low resistance to windthrow due to shallow rooting system. (Note – this is the main natural disturbance type in Ss ecosystems). Deeper rooting up to 2 m has been identified on well-drained upland sites likely reducing individual susceptibility.
- ○ Low risk of snow-breakage in most cases as Ss does not grow in areas of high snowfall.

Major Pests

- ✗ Spruce weevil *(Pissodes strobi)* is a severe problem in all but the Queen Charlottes and geographic areas within the CWH (e.g., MSZ, vm1, vm2, and vh2).
- ✗ Spruce beetle (*Dendroctonus rufipennis*) can be a problem especially in areas of high blowdown and slash accumulations (in the Vancouver Forest Region, it has only been a problem in the Bella Coola Valley).
- ✗ Ss is susceptible to decay organisms when wounded. Both root and butt rots (especially *Neolentinus kaufmannii*) can cause value and volume losses. Note – root damage is a direct entry point for decay organisms – a problem for species with shallow rooting where ground-based partial cutting systems are used.
- ✗ Ss is susceptible to *Heterobasidion annosum* and *Phaeolus schweinitzii.*

General

- ○ Grows mainly in the CWH. It occurs in the lower MH, northern subcontinental BWBS and rarely in the CDF.
- ○ In BC, Ss grows mainly in mixed-species stands with Hw as the dominant species. Other associates include: red alder, black cottonwood, Cw, Yc, Sx, and Fdc. Ss does not tolerate extremely high temperatures or dry soils.
- ○ Ss is a desirable timber-producing tree limited in potential use by the terminal weevil. Use of nurse-tree shelterwoods to establish Ss in floodplains and to minimize weevil attacks has been attempted with some success.
- ✗ Partial cutting prescriptions must be planned to avoid wounding or root damage as decay will ensue.

[1] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

Interior Spruce and Partial Cutting

Picea spp. (Sx)

Suitable Silvicultural Systems

- ○ **Natural and Nurse-tree Shelterwoods** – Less suited than its true fir associate Bl. Somewhat suited to growth beneath aspen in a nurse-tree shelterwood (e.g., in the BWBS).
- ○ **Other Forms of Shelterwood** – Suitable, as some shade is good for germination. Full removal cut maximizes growth of understorey stems.
- ○ **Single Tree Selection or Irregular Shelterwoods** – Can be used if care is taken to promote Sx over its more shade-tolerant associates (Bl and in some cases Hw) through stand tending or intermediate harvests.
- ✗ **Seed Tree Systems** – Somewhat risky due to potential for windthrow.

Tolerances

- ○ **Shade** – Moderately shade tolerant (less tolerant than Bl, its most common associate).
- ○ **Growing Season Frost** – Moderate to high tolerance to frost; varies by area.
- ✗ **Heat/Drought** – Susceptible to lethal stem girdling on hot dry exposed slopes (often on duff). Moderately tolerant of drought
- ✗ **Fire** – Low tolerance due to thin bark and predominantly shallow roots.
- ✓ **Water Surplus** – Tolerant of water surpluses, common on moist to wet sites.
- ○ **Nutrients** – Moderate tolerance of nutrient deficiencies; absent or rare on very poor sites.

Effects of Harvest Damage on Understorey Stems

- ○ No information available (refer to FRDA Report No. 230, pp. 102–103).

Effects of Harvest Damage on Leave-trees

- ✗ Wounding can reduce vigour and increase the risk of heart and butt rots as well as increase their susceptibility to spruce beetle (*Dendroctonus rufipennis*) attack especially where windthrow or slash has increased beetle populations.

Natural Regeneration

Prolific Seed Years

Every 2 to 5 years (variable by area). Longer between and fewer good crops at higher elevations and latitudes.

Seed Travel Distance

Light seeds can travel far – up to 200+ m, depending on leave-tree density and slope position.

Seed Distribution Method and Timing

Wind in late summer; some are dispersed throughout the winter into the next summer.

Seed Production

Forty years old for collectable amounts. Older healthy dominant trees provide the greatest amount of seed (150 years plus).

Seed Losses

Numerous insect pests, not likely a problem in good seed years.

Germination Needs

- ✓ Germination occurs on all seedbeds; exposed mineral soil has been found to be the most favourable.[1]
- ✓ Decaying or rotten wood is often favoured in undisturbed forest understorey where lethal temperatures are less prevalent.
- ✗ Burned seedbeds are not preferred, unless mineral soil is exposed.
- ○ Light to moderate shade appears to benefit germination and early survival. The need for shade likely is greater on hot dry sites.

[1] Mineral soil has the ability to retain moisture and limit lethal temperatures reducing their risk of heat or frost damage.

Forest Practices Branch
Ministry of Forests

✓ Recommended ✗ Use caution ○ Informational

Interior spruce (Sx)

✗ Natural regeneration on wet rich ecosystems is low, likely due to vegetation competition.

Strategies for Enhancing Natural Regeneration

✓ Provide exposed mineral soil on mesic (fresh to moist) sites. Leave some level of shade on hot, dry sites. Keep openings relatively brush free. Coincide regeneration cuts with good seed years.

Growth Potential

○ Best growth is found on moist, nutrient very rich sites. Once established, optimum growth is obtained when the overstorey is removed. Site index at breast height age 50 years ranges from 6 to 21 m.

○ Height growth of 10 cm/yr to age 5 is common for planted stock.

Windthrow[2] – Snow-breakage

○ Variable resistance to windthrow depending upon location; wetter sites restrict rooting to near the surface, reducing windfirmness. Generally better rooted on drier sites where Sx forms extensive lateral roots that can penetrate over 2 m into the soil.

○ Broken or windthrown trees often infected by Tomentosus or butt rots.

✓ Low risk of snow-breakage in most cases. Breakage can occur in high snowpack areas.

Major Pests

✗ Old-growth spruce is highly susceptible to spruce bark beetle *(Dendroctonus rufipennis)*. Spruce bark beetle is a major concern in areas with unharvested windthrow or slash. Management is necessary.

○ The spruce budworm *(Choristoneura occidentalis)*, contrary to its name, is more a threat to Douglas-fir than it is to spruce, but spruce is susceptible.

✗ Spruce is susceptible to Armillaria and Tomentosus root rots.

✗ Diseases caused by wood-rotting fungi (*Phaeolus schweinitzii, Fomitopsis pinicola* and *Phellinus pini*) are often associated with scarring from fire.

✗ Spruce weevil *(Pissodes strobi)* is a problem in young spruce stands. In high-hazard sites, Sx use should be limited (e.g., 25% maximum).

General

✓ Interior spruce can be suppressed for long periods (50 to 100 years) under a range of canopy conditions. Release of healthy stock is often quick and significant, allowing the spruce to rapidly occupy dominant crown positions. Height response is relative to overstorey removal with the greatest response in full sunlight. Older advance regeneration should be assessed for stem rot if release is planned.

✓ Partial cutting to perpetuate spruce depends upon its make-up in the original stand. Because Bl is more shade tolerant, systems with high residual basal area retention will often shift species dominance to Bl. This can be managed through precommercial thinning and other intermediate entries.

○ Single tree selection is an option where harvest damage can be minimized. Residual basal areas of 20 to 30 m^2/ha are likely appropriate to promote regeneration and maintain productivity.

[2] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

Yellow-cedar and Partial Cutting

Chamaecyparis nootkatensis (Yc)

Suitable Silvicultural Systems

✓ **Natural and Nurse-tree Shelterwoods** – Potentially suited under moderately dense canopies; growth under a dense overstorey may result in failure to develop an upright trunk.

○ **Other Forms of Shelterwood** – Shelter may benefit Yc establishment on frost-prone sites. At higher elevations with late snow melt, Yc regeneration is often associated with tree islands (i.e., group shelterwood).

○ **Singletree Selection or Irregular Shelterwoods** – Consider strip or group applications to mimic natural disturbance patterns.

✗ **Seed Tree Systems** – Not suited due to low natural regeneration success.

Tolerances

✓ **Shade** – Tolerant to very tolerant. Reports vary. Some indicate it is less shade tolerant than Hw (tolerant); others indicate it has similar tolerance to Ba (very tolerant).

○ **Growing Season Frost** – Tolerance to frost is moderate to low. Snow provides needed protection.

✗ **Heat/Drought** – Low tolerance to heat girdling. Moderate to low tolerance to drought. Has established on talus slopes. Drought tolerance is lowest in the spring at the time of shoot elongation.

✗ **Fire** – Low tolerance due to thin bark and predominantly shallow roots.

✓ **Water surplus** – High tolerance to flooding and seasonally saturated soils. Common on waterlogged soils.

✓ **Nutrients** – High tolerance of nutrient deficiencies, often found on poor sites.

Effects of Harvest Damage on Understorey Stems

○ Unknown. It is flexible, making it less prone to breakage when young.

Effects of Harvest Damage on Leave-trees

✗ Basal scarring can result in fungal decay and reduced value.

Natural Regeneration

Prolific Seed Years
Four or more years between large cone crops.

Seed Travel Distance
Likely less than 100 m.

Distribution Method and Timing
Wind; fall and early winter.

Seed Production
Unknown age for collectable quantities; regeneration primarily with cuttings.

Seed Losses
Minimal.

Germination Needs

○ No information on preferred germination medium.

✗ Generally poor survival of natural regeneration. Protection from frost and deep snow may be required.

Strategies for Enhancing Natural Regeneration

✓ Maintenance of tree islands helps protect regeneration from desiccating winds, blowing ice particles, and snow creep. They also accelerate snow melt which extends the growing season.

○ Due to poor reproductive success, planting of Yc is recommended to promote a Yc presence in the future stand.

Growth Potential

○ Yc site index at breast height age 50 years ranges from 8 to 24 m.

✗ In general, Yc has slower growth than its associates (e.g., Ba, Hm).

Forest Practices Branch
Ministry of Forests

✓ Recommended ✗ Use caution ○ Informational

Yellow-cedar (Yc)

Windthrow[1] – Snow-breakage

- ○ In general, Yc likely has a moderate resistance to windthrow. Open crowns reduce sail area, however in wet soils shallow rooting may reduce stability.
- ✓ Tolerant of heavy snow loads due to its flexible crown and drooping branches.

Major Pests

- ✓ Few insect pests.
- ✗ Trees, especially at low elevations, may die due to yellow-cedar decline, an affliction that may be tied to warming weather patterns.
- ✗ For the most part the wood is durable because of nootkatin and chamic acid, natural fungal inhibitors.
- ✗ *Phellinus weirii*, cedar form, and *Postia sericeomollis* (cedar pocket rot) can cause butt rot. *Phellinus pini* (red ring rot) can cause heart rot.

[1] Windthrow is strongly influenced by topographic exposure, soil, and stand conditions. Root anchorage impeded by smooth rock, wet, or compact soils will increase the susceptibility to windthrow. Exposed, dense stands suddenly opened by harvesting may be highly susceptible to windthrow.

General

- ○ Yc grows predominantly in the CWH and MH zones.
- ○ When managed with other conifers on better sites, it may require active management to promote vigour, as other species may be able to outgrow it.
- ○ It appears to have a strategy of tolerating suboptimal sites where it can dominate (wet and nutrient poor).
- ○ Because of its inconsistent success at natural regeneration, planting of Yc should be explored (seedlings produced from both cuttings and seed).